[redacted] Group 4

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E	Para. 3.2	LEM	NAS 9-1100	1-14-63

Type I, NASA Approval Pending

Primary Code 022

N79-76237

REPORT

NO. LPL-2-1

DATE: 15 May 1963

FACILITIES PLAN

FOR

PROJECT APOLLO

LUNAR EXCURSION MODULE [redacted]

CODE 26512

LEM Team

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LEM Facilities Coordinator

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

[redacted]

This document contains information affecting the national defense of the United States, within [redacted] 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by [redacted]

UNCLASSIFIED WHEN FIGURE 1-3 AND 5-2 ARE REMOVED

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FACILITIES PLAN

FOR

PROJECT APOLLO - LUNAR EXCURSION MODULE

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1.0 INTRODUCTION

1.1 Scope

The Facilities Plan for the LEM program is Type I documentation and is required under paragraph 3.2 of Exhibit E, dated 20 December 1962, of Contract NAS 9-1100 dated 14 January 1963. This plan covers all of the Grumman and Government facilities required to carry out the LEM development, manufacturing and operational programs.

There are some aspects of the Facilities Plan which are unique compared to the other LEM plans. The Facilities Plan does not outline any work or hardware which is funded by the LEM contract. The facilities to be acquired for use by Grumman in-house are capitalized by the Corporation. The Government facilities are provided or acquired by NASA. For both types only the verification and coordination of requirements is charged to LEM Facilities Planning. Ground Support and Special Test Equipment required in the LEM program are handled by the GSE Subsystem Engineer who also defines the requirements for Government Furnished Property of either a GSE or expendable nature.

1.2 Organization

The Grumman Corporation provides for accomplishment of facilities planning by using the services of several departments as shown in Figure 1-1. These departments also actually design and procure facilities and provide other services. For the LEM Program, it was considered necessary to establish a LEM Facilities Office to coordinate the planning to be implemented by the operating departments in providing Grumman facilities and to coordinate the requirements for Government facilities. This office is illustrated in Figure 1-1. The LEM Facilities Office includes personnel responsible for specific areas; some of these are directly assigned by other LEM managers as shown.

1.3 Operating Methods

1.3.1 Grumman Facilities

Following the contract definitization, about two months were devoted to predicting what additional Grumman facilities are required to carry out the LEM program and in preparing a budgetary cost estimate. In February 1963, the Corporate Management appropriated $6.9M for facilities for the LEM Program and reserved decision on providing a new LEM manufacturing plant. These corporate funds are to be expended as required at the discretion of the Vice President, Director of the LEM Program. In practice, all items are processed through the Fixed Assets Committee because the procedures are in existence and a duplicate channel is neither necessary nor desirable.

Requirements for facilities in Grumman are generated by personnel in the various LEM groups as the program progresses. The availability of required facilities is defined by the operating Departments. If the required facility is not available, the LEM personnel contact the LEM Facilities Office as follows:

a. The requirement is justified by a LEM Group Manager or his representative and

b. a check is made on the requirements for similar facilities for other LEM functions and for other corporate programs, on the schedule requirements, on the suitability of the proposed location, etc., and

c. the item is approved for procurement against the LEM Fixed Assets budget.

For complex items a Facility Project Man is appointed to coordinate detailed plans for the facility such as location, size, schedule, cost, and may include a survey of availability of similar facilities in the Government or industry. This effort is charged to Facilities Planning. When an item is approved for procurement, all subsequent costs, including design and installation, are company funded.

The more complex facility items are those for engineering tests and are discussed in Section 3. In general, this is a compilation of a cross cut from the LEM Test Plan, LPL-600-1. The acquisition of these facilities is summarized in Figure 1-2.

1.3.2 Government Facilities

The requirements for Government facilities for the LEM program are generated by the test planners in either the Engineering Group or the Test and Support Group. The function of the LEM Facilities Office is to see that all the requirements are defined, that all of the requirements for a given facility are coordinated, and that the requirements for all of the facilities are coordinated and made known to NASA in this document or by interim correspondence.

For the WSMR LEM Test Facility, a coordinator is provided and is backed up by a committee representing various technical areas. The technical Criteria for the facilities for propulsion system tests was prepared and supplied with other requirements to an architect-engineering consultant (Burns and Roe, Inc., Hempstead, N.Y.) who prepared the Design Criteria and Conceptual Design. It had earlier been understood that Grumman would handle a facilities contract for the design and construction of the LEM Test Facility at WSMR. However, at this writing the plan is that NASA will use the Army Corps of Engineers who will contract an A-E for the design.

It is expected that a technical advisory committee will be established at the A-E design office and that Grumman will provide additional or revised requirements via a representative on the committee.

The requirements for AMR facilities are so complex that a coordinator is provided. Establishment of a committee to facilitate defining and screening the requirements (similar to that for the WSMR LEM TF) is under consideration.

The requirements for facilities at AMR, AEDC, MSC and WSMR are discussed in separate sections. In general, these data are a compilation of a cross cut of the LEM Test Plan, LPL-600-1. The requirements are summarized in Figure 1-3.

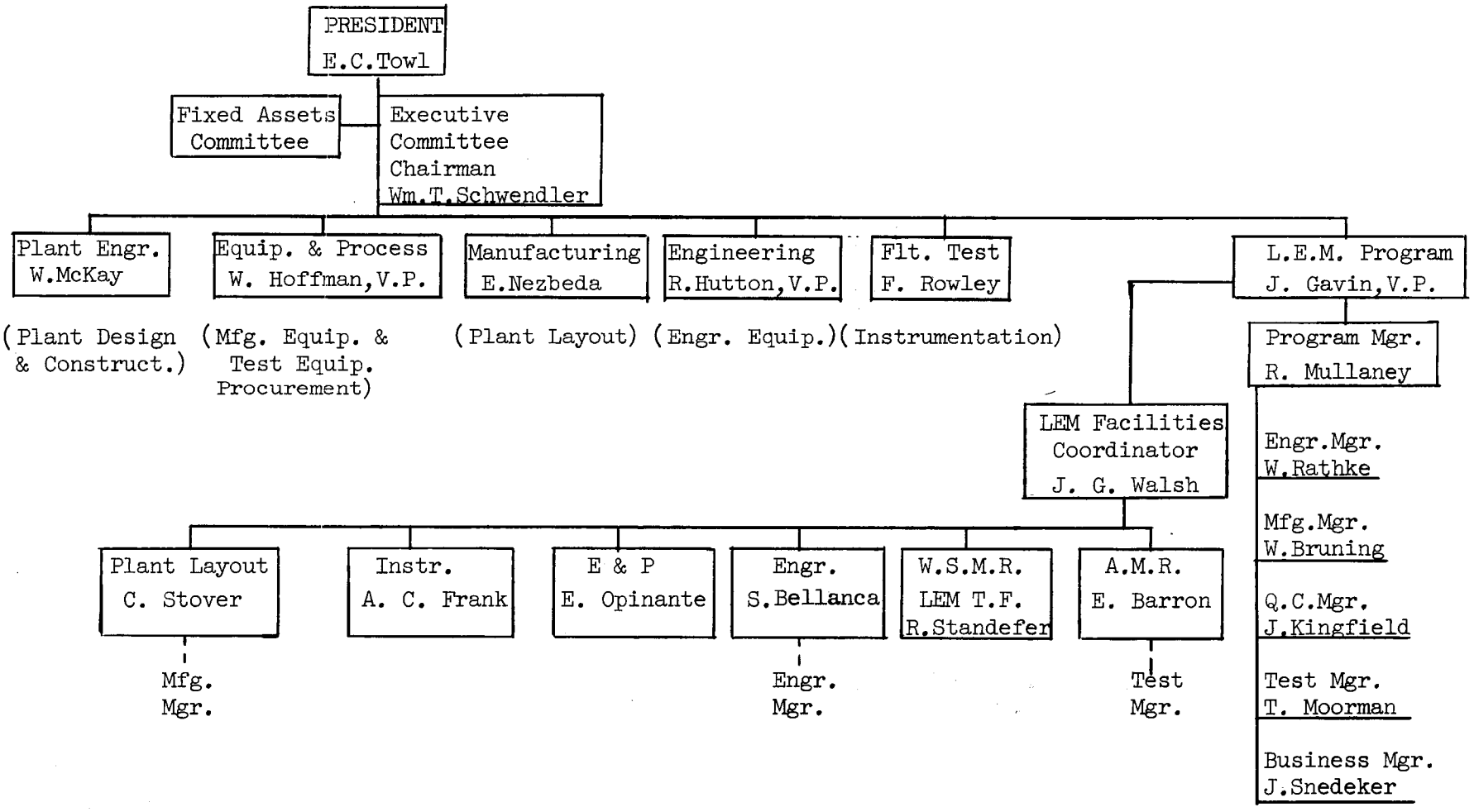

Figure 1-1

FACILITIES RESPONSIBILITY IN GRUMMAN

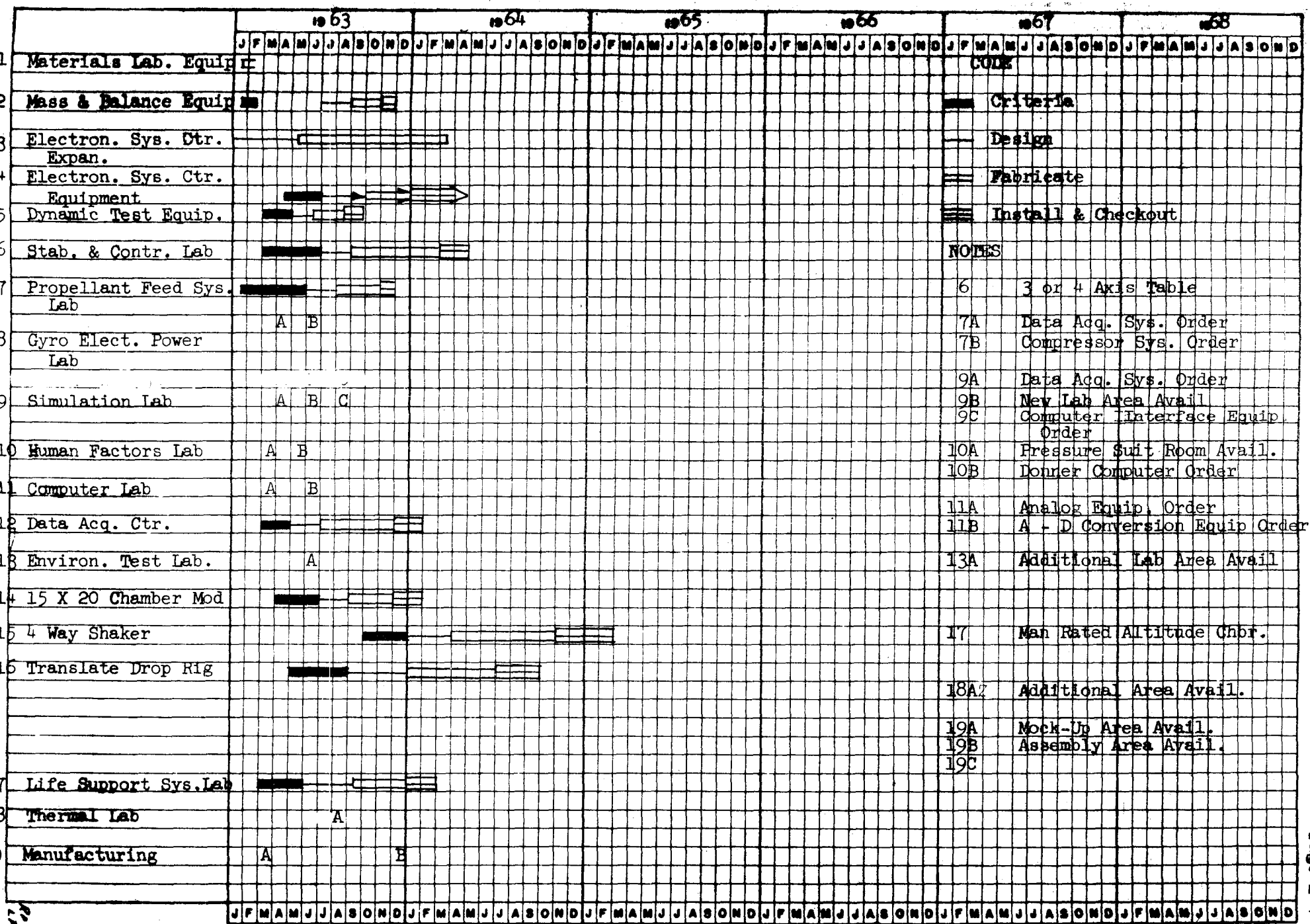

FIGURE 1-2
ACQUISITION OF GRUMMAN FACILITIES

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

Page 1-4

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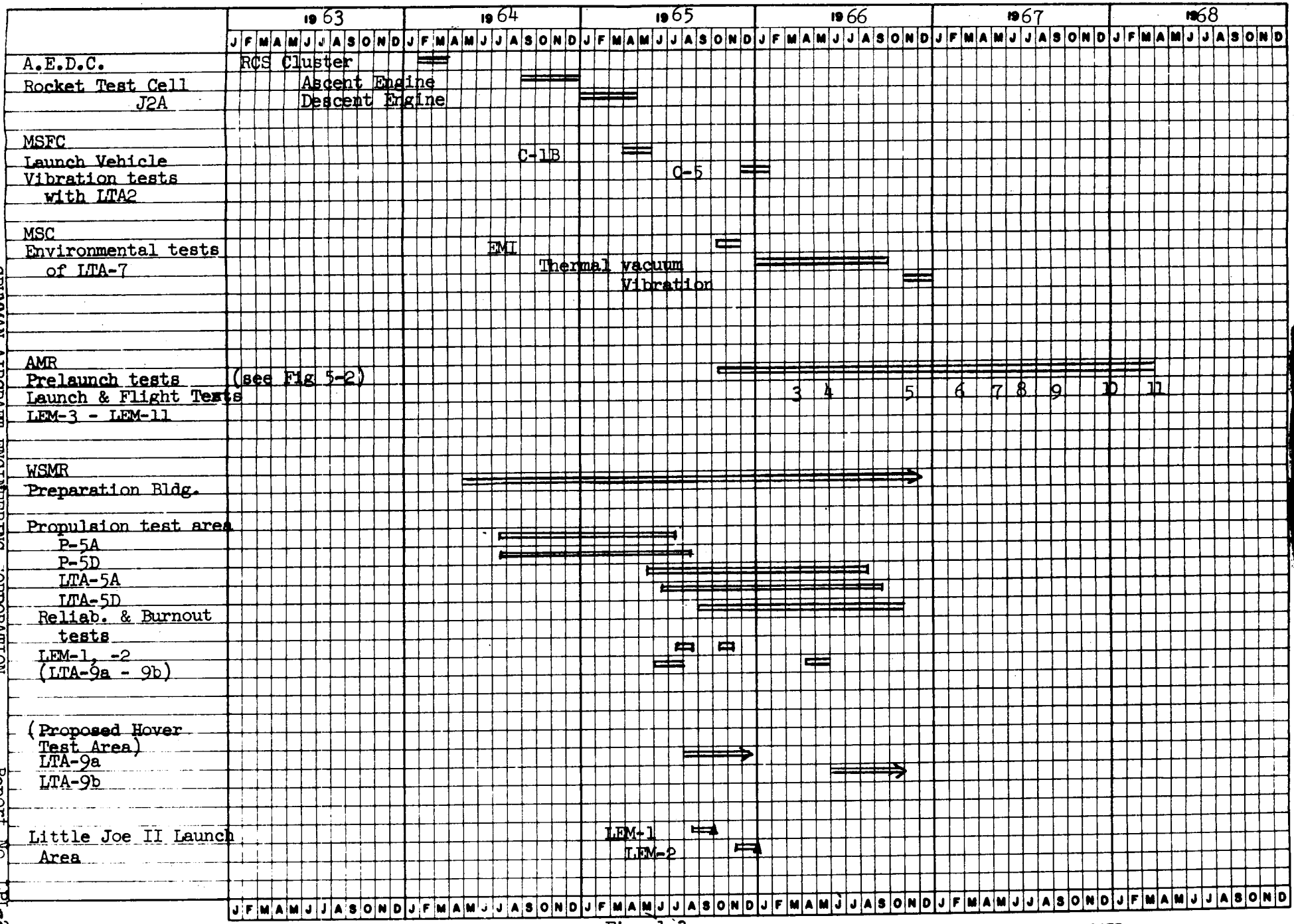


Fig. 1-3

SCHEDULE FOR USE OF GOVERNMENT TEST FACILITIES

DATE _____

2.0 GRUMMAN MANUFACTURING FACILITIES

The Grumman proposal for the LEM stated that a new manufacturing plant in excess of 80,000 sq. ft. would be provided. The contracted schedule requires a significantly lower production rate and therefore less floor area is required. The Manufacturing Department has conducted a study of the entire corporate manufacturing facility situation. The resultant plan for the LEM is fully discussed in Section 2 of "Manufacturing Plan for Project Apollo - Lunar Excursion Module", GAEC Report No. LPL-850-1, 14 May 1963. Basically, it consists of building up subassemblies in several areas suited for the tasks and performing assembly, installation and test in an integrated LEM area in Plant 5.

3.0 GRUMMAN TEST FACILITIES

In order to implement the LEM program, GAEC intends to provide as corporate assets certain facilities and equipment. Significant items that are currently being planned are shown in chart form on the following pages. The detail that can be presented in this report is limited at this time.

MATERIALS LAB

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Spectrophotometer	UV, visible, near IR	Materials development testing	
Spectrophotometer	IR	Same as above	
Ultra-violet vacuum chamber	Vacuum chamber (10^{-} torr) w/ultra violet source	Same as above	
Thermal vacuum electro-balance chamber	Vacuum chamber (10^{-} torr) w/provisions for weight loss experiments.	Same as above	
Miscellaneous equip.	Lab equip. incl. balances, special gages, etc.	Same as above	

MASS AND BALANCE

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Mass Property Measuring Facility	a) Propulsion prototype #4 C.G. Measurement Facility b) Propellant Tank Inertia Measurement Facility c) 3-Axis LEM Moment of Inertia Measurement Facility	Determine mass properties of the LEM as a function of propellant usage. Substantiate the calculated mom. of I values for complete LEM. Check weight and C.G. offset from thrust axis on each LTA and LEM (P-4, P-5, LTA 7, etc.)	These are three separate facilities which may use some common instrumentation.
Two Axis C.G. Locator	No activity		

ELECTRONIC EQUIPMENT PLT. 14

AND PLANT 14 EXPANSION

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Electronic Equipment	A separate listing of these items is being prepared, and will be covered when it becomes available.		
Electronics System Center (GAEC-Plt.#14)	10,000 sq. feet of addition to Plt. 14 + other space in main building will be devoted to LEM electronics development and subsystem testing.	Subsystem development, system integration (development), functional checks of all incoming electronic equip.	

DYNAMIC TEST EQUIPMENT

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Random Signal Processing Equipment	Log frequency converter, Log voltmeter and converter, X-Y Recorder, 6 channel tracking filter system.	Development tests, LTA 3 & 4	
Impedance Meas. System	Impedance head, 2 channel tracking filter and readouts	Development tests, exploratory tests on beam and simulated structures.	

STABILIZATION AND CONTROL LABORATORY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Flight Attitude Table	Flight attitude table, power supply and control console	LEM FCS integration and development tests.	

PROPELLANT FEED SYSTEM TEST FACILITY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
P.F.S. Facility	High pressure test cells, helium regulating system, handling equip., instrumentation, preparation area, building for control, instrumentation and bench tests.	Development and acceptance tests of propellant storage and feed systems including ascent, descent stages and RCS system.	Control console, test benches, subst. propellant storage and conditioning are S.T.E.

CRYOGENIC ELECTRICAL POWER SYSTEMS TEST LABORATORY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
EPS Test Laboratory	Cryogenic-hazardous fluid test bays, remote control room, assembly area, cryogenic storage and equipment, data acquisition.	Development of interface and actual mating of vendor components and assemblies into a power generation section. Development and reliability testing of power generation section mated with distribution section.	

SIMULATION SYSTEMS

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
3 or 4 Gimballed Table	No detailed information at this time.	Task simulation, mission simulation IIB, IIIB, V	In S&C lab.
30 Chabnel Unidap Multiplexer	A device allowing the recording of data on 30 chan. using one tape recorder.	To be used on all simulators and other LEM tests - All Phase "A" programs.	
Simulator-Computer interface equip.	No detailed info at this time.	Support of simulators.	
Data acquisition	No detailed info at this time.	Support of simulators.	
Miscellaneous	No detailed info at this time.		
Lab expansion	6500 sq. ft. R&D, some high bay.		

HUMAN FACTORS LAB

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Computer Equip.	Miscellaneous, incl. digital data acquisition, donner amplifiers, servos, etc.		

COMPUTER LABORATORY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
IBM 7094 Expansion	A-D and D-A link	LEM & Phase Systems Simulation Program	
Analog Computer	370 amplifiers + non-linear equip. & plotters	Simulation programs & trajectory analysis.	
Digital comp.	2nd IBM 7094		

NOTE: A general expansion and consolidation of the GAEC computer facilities is in progress. Certain items that are required specifically for LEM will be covered in detail in these charts, however other items that have general corporate use including LEM will not be covered. Detailed information concerning the latter will be made available to NASA if required, when it becomes available.

DATA ACQUISITION CENTER

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Instrumentation Equipment	1000 channel digital tape recording system with conditioners and cabling	Thermal vacuum tests: TM-2, LTA-4	
	50 channel analog tape recording system with conditioners and cabling	Vibration tests: LTA-3, LTA-4	
D.A.C. Room	150 sq. ft. room will be installed near env. test area.		

ENVIRONMENTAL TEST LABORATORY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
Four way shaker system	Detailed description not available.	Vibration Tests of LEM	
Drop Test	Translation Drop Test Rig	Drop tests of full scale LEM landing systems and LEM.	Suitability of Apollo impact rig at Downey in study.
Space Simulator Modifications	Cold wall modifications, rework of blowers & pumps to handle O_2, additional support or stiffening of base to handle increased loads.	TM-2 thermal vacuum tests, also LTA-4 tests.	
Hydrostatic Tank	Detailed description not available.		
Miscellaneous			
Lab Expansion	4,700 sq. ft. high bay adjacent to existing lab		

LIFE SUPPORT SYSTEM LAB

FACILITY	DESCRIPTION	TEST PROGRAMS: SCHEDULED	TEST PROGRAMS: REMARKS
ECS Test Facility	ECS Internal Environment Simulator	Dev. testing of LEM ECS - Testing of prop. hardware revisions, failure investigation	This facility may also be used by H.F. if man rating of facility is approved at conclusion of initial study about June 1, 1963.
Lab Expansion	1000 sq. ft.		

THERMAL LABORATORY

FACILITY	DESCRIPTION	TEST PROGRAMS SCHEDULED	REMARKS
1. Integrating Sphere	Gier-Dunkle AIS 6B to be used for UV & vis. measurements	Radiation characteristics in UV and vis. range of thermal control coatings-determination of UV degration of materials.	
2. Mod. Hohlraum refl. mod. 13	Modifications to existing equip. to increase accuracy and reliability of measurements.	IR radiation characteristics of thermal control coatings.	
3. Far IR grating spectrophotometer	To increase spectral range of measurements of radiation characteristics.	Same as 2. Increased capability at lower sample temperatures.	Will allow measurements to 200 .
4. 4" Vacuum evaporator	Pumping station & bell jar for vacuum surface deposition.	Preparation of materials for thermal contact resistance reduction.	
5. High temp. cond. device	Measurement of thermal conductivity at temperatures up to 20000°F.	Verification of vendor data for propulsion system components.	
6. Hot Gas Generator	Hot gas supply for plume effects tests, fire in the hole study,etc.		
7. Search Light	5' Beam for Collimated Light Source.	1/6 scale form factor model.	
Miscellaneous			
Lab Expansion	Lab area will be increased by 2000 sq. ft.		

4.0 SUBCONTRACTORS' FACILITY REQUIREMENTS

At this time, there is no anticipation of requirements for new facilities at our subcontractors' plants to be funded by Grumman or NASA.

5.0 ATLANTIC MISSILE RANGE

5.1 Introduction

This section describes the facilities required for the proposed LEM pre-launch tests at AMR. Also included are the LEM checkout plan (Fig. 5-1) which outlines a typical preliminary LEM test sequence at AMR, and the facilities utilization schedule for all LEMs at AMR (Fig. 5-2). This schedule is based on the current Saturn, Apollo, and LEM launch schedule and indicates that occasionally 2 LEMs will occupy certain buildings concurrently.

Each required facility is presented building by building as encountered in the LEM checkout plan with a description of the tests proposed in each area and the required equipment for performance of the tests. Any items of special consideration will be discussed where applicable, (e.g., the use of cryogenics in any area other than the cryogenics building).

The facilities covered are:

Section	
5-2	Operations and Checkout Building
5-3	Environmental Control Systems Building
5-4	Hypergolic Test Building
5-5	Cryogenics Test Building
5-6	Weight and Balance Building
5-7	Static Test Complex

5.2 Operations and Checkout Building

5.2.1 Subsystems Functional Tests - These tests will be performed in the Assembly Area during the first week at AMR on each LEM following receipt and inspection. These tests will be repeated in this area during the seventh week at AMR (as shown on the LEM Checkout Plan, Fig. 5-1) prior to insertion in the environmental test chamber. The tests will be performed on the completely assembled LEM and will demonstrate the functional capability of each of the subsystems as follows:

a) Structures subsystem - Leak checks.
b) Electrical Power Supply subsystem - Distribution and load checks.
c) Communications and Instrumentation subsystem - All communications will be checked.
d) Environmental Control subsystem - Individual suit loops will be charged and tested and equipment cooling loop will be checked.
e) Navigation and Guidance subsystem - IMU, OMU tests.
f) Stabilization and Control subsystem - Exercise input commands
g) Reaction Control subsystem - Commands from the Stabilization and Control Subsystem will be used to test the RCS without propellants in addition to manual mode tests.

h) Propulsion Subsystem - No propellants

i) Ascent Stage - N & G automatic and manual mode commands will test ascent engine and valve operation.

ii) Descent Stage - N & G automatic and manual mode commands will be used to check valve operation, throttling, and gimballing.

5.2.2 Required Equipment

Class III - Checkout Equipment, Class IV - Servicing Equipment. The checkout equipment will be capable of isolating malfunctions of combined subsystems down to the replaceable element level. The servicing equipment will supply fluids, cooling, etc.

Class IV
a. Fluid and gas supply unit
b. Equipment cooling unit

Class III
c. Computer equipment
d. Digital command system
e. Data collection system
f. Data link
g. Display equipment
h. Closed circuit TV

5.2.3 Mate and Alignment Tests - These tests will be performed on the mated LEM, CM & SM. The purpose of the tests is to verify and test all spacecraft interfaces prior to combined subsystem functional tests and mission simulation. The tests will be started during the sixth week at AMR as shown in Figure 5-1. They will consist of:

a) Mechanical mating tests between SM and LEM with booster adapter.
b) Mechanical mating tests between LEM and CM.
c) Verification tests of LEM, CM interface to include the following.
   i) Electrical
   ii) Communications LEM - CM

5.2.4 Required Equipment

Class III and Class IV as outlined in para. 5.2.2.

5.2.5 Mission Simulation Tests - The mission simulation tests are performed on an integrated S/C in an altitude chamber with a complete crew. Thest tests will verify subsystem operation and mission capability in a simulated space environment. These tests are expected to start during the ninth week at AMR (Fig. 5-1) and will follow instrumentation calibration.

The tests consist of functional checks of all subsystems.

5.2.5.1 Pre-Mission simulation - The LEM will be installed in the space chamber without an astronaut and instrumentation will verify structural integrity, ECS operation and subsystem performance in space environment. All normal operations in the mission phases will be performed in chronological order.

5.2.5.2 Pre-Flight Tests - With man in the LEM and the chamber pressure lowered, this test duplicates the checkout of LEM performed in trans-lunar flight. A CM/SM simulator is mated to the LEM. This checkout verifies subsystem operation prior to simulated lunar descent.

5.2.5.3 Lunar Descent - N & G inputs to propulsion and S & C inputs to RCS will be simulated to verify proper operation during lunar descent. All displays and subsystem status will be monitored during this and the following tests.

5.2.5.4 Lunar Landing - Altitude control maneuver inputs are simulated to the propulsion subsystem and RCS for hover and landing tests.

5.2.5.5 Lunar Operations - The LEM will be de-pressurized, the exit hatch operated and the LEM re-pressurized. Suit telemetry and man/LEM communications will be tested.

5.2.5.6 Lunar Launch - N & G command and synchronization with the CM will be simulated for this test.

5.2.5.7 Lunar Orbit and Rendezvous - Manual and automatic position inputs will be supplied for the simulated rendezvous.

5.2.5.8 Post Mission Simulation - Pressurize chamber for astronaut egress.

5.2.6 Required Equipment

Class III and Class IV same as para. 5.2.2, plus a man rated space chamber and a CM/SM Simulator.

5.3 Environmental Control Building

5.3.1 Environmental Control Subsystem Tests - These tests will verify subsystem leak rate, pressures, flows and performance under varying load conditions. Tests will be performed on the assembled ascent stage. The tests will start during the second week at AMR. Metabolic simulators will be used and equipment heat load will be simulated. High pressure leak checks and calibration will be performed with N_2 in system. ECS operation will be tested with actual coolant gases in suit loops and equipment loops at operating pressure. All valves and operational modes will be checked.

5.3.2 Required Equipment

Class III and Class IV same as para. 5.2.2, plus:

a) Vacuum pump
b) Fluid and Gas Test Unit - Controls and monitors fluid and gas flow, quantity, pressure and temperature.

Class IV. This equipment will transfer gases and/or liquids to and from the LEM (i.e., O_2, N_2, glycol, water, H_e, etc.).

5.4 Hypergolic Test Building

5.4.1 Reaction Control Subsystem Acceptance Tests - These tests on the assembled ascent stage verify Reaction Control subsystem operation and safety. The tests will be performed during the third week at AMR and consist of:

a) Pressure checks on the subsystem to measure leaks, etc.
b) Pressure regulator test.
c) Propellant servicing and quantity calibration (RCS tanks and ascent engine tanks).
d) Static firing of the RCS will verify performance. Pre-determined firing sequences in both automatic and manual mode will be applied. Flow from both the RCS tanks and the ascent engine tanks will be tested during firing.
e) Propellant transfer, purge and dry.

5.4.2 Required Equipment

a) Propellant transfer unit to supply fuel and oxidizer to tanks and helium for pressurization. This unit also drains tanks and measures propellant weight, pressure, temperature and flow.
b) Purge and dry unit.
c) Electrical circuit checker to measure electrical circuit input and valve response.
d) Static firing stand provides a mounting base for LEM and protective structure for personnel and equipment nearby.
e) Static firing monitor and control console should be used for test sequence control, emergency shutdown and displays. This unit monitors and measures chamber temperatures, pressure flows and safety parameters.

5.5 Cryogenics Building

5.5.1 Electrical Power Supply Subsystem Acceptance Tests - The fuel cell operational capability and electrical power distribution will be demonstrated by these tests. Cryogenics will be used in all cryogenic tanks of the ascent and descent stages and flow and leakage will be measured. Tests consist of:

a) Chill down and reactant fill tests to measure boil off rates and leakage at low temperature.
b) Functional mechanical tests to check valve operation, consumption and flow rates, and water production.
c) Functional electrical tests - The fuel cell outputs will be monitored to measure voltage and current under varying load conditions.

5.5.2 Required Equipment

a) Cryogenic supply and test console to supply LH_2 and LO_2. Also monitors pressure, temperature, weight and flows.

b) Fuel cell test console - Supplies electrical loading, monitors power distribution, pressures, voltages, etc.

5.6 Weight and Balance Building

5.6.1 Weight and Balance Tests - Weight and inertia properties of the separate ascent and descent stage will be obtained during the fourth week at AMR prior to engine firing. Weighing of the completely mated LEM will follow the static firing of the descent engine. Steps are as follows:

a) Static weighing of the LEM ascent stage will be performed followed by rotation about the x-axis and a second weighing for cg computation.

b) Static weighing of LEM descent stage as described in (a).

c) Static weighing of complete LEM (ascent plus descent plus landing gear).

The weight and cg of propellants will be determined analytically and from quantity calibration determined during static firing tests.

5.6.2 Required Equipment

Weight and Balance equipment - To support LEM with three load cells and permit rotation of these cells about the x-axis.

5.7 Static Test Complex

5.7.1 Propulsion Subsystem Acceptance Tests - These tests will be performed on the LEM ascent stage and then the LEM descent stage mated to the ascent stage, to verify functional capability of the LEM Propulsion Subsystem. The tests will be performed during the fifth and sixth weeks of checkout.

Tests on the ascent stage propulsion will be as follows:

a) System pressure check
b) Engine alignment
c) Propellant servicing and quantity calibration
d) Static firing. Pre-determined firing sequences in automatic and manual control modes will be used. Thrust, flows, pressures, temperatures, etc. will be monitored and recorded.

Tests on the descent stage propulsion while mated to the ascent stage will be the same as above with the addition of the following:

d) Static firing. Throttling tests of the engine. Gimballing tests on the descent engine.

5.7.2 Required Equipment

Servicing Equipment includes the following:

a) Propellant transfer unit - Supplies and transfers fuel and oxidizer to LEM tanks. Supplies helium for tank pressurization. Drains tanks and measures propellant weight, pressure, temperature and flow.

b) Purge and dry unit.

c) Pressurization test console - controls valve operations, flows and leakage.

d) Electrical circuit checker - Measures and controls electrical inputs to propulsion units.

e) Gimballing test unit - Supplies power for gimballing the descent engine and controls gimbal actuation valves.

f) Static Firing Stand - This vertical stand provides a base and thrust frame for the LEM and must be equipped with an altitude simulation system to allow the nozzles to flow full.

g) Static Firing Control Console - This unit provides the test controls, emergency shutdown control and monitors chamber temperature, critical vibrations, pressures, temperature flows and thrust.

5.8 Vertical Assembly Building

5.8.1 Alignment Tests - These tests will be performed on the spacecraft and launch vehicle after mating to verify proper alignment.

5.8.2 Required Equipment - Alignment Equipment: provides for precision alignment of the Space Vehicle.

5.8.3 Combined Subsystems Functional Tests - These tests will be performed after mating and alignment of booster and spacecraft to verify functional capability of all subsystems. The tests will take place during the twelfth week at AMR. They are the same as listed in para. 5.2.1 plus checking the electrical interface between LEM and CM.

5.8.4 Required Equipment - Class III and Class IV: same as para. 5.2.2.

5.8.5 Mission Simulation Tests - The scope and purpose of these tests are the same as described in para. 5.2.5, with the following exceptions:

a) The tests shall not be conducted in an environmental chamber.
b) LEM-CM docking will not be performed.
c) The tests will take place during the fourteenth week at AMR.

5.8.6 Required Equipment - Not defined.

5.9 Launch Complex

5.9.1 Flight Readiness Demonstration (Dry Countdown)- These tests shall be performed on the LEM in the mated spacecraft and launch vehicle to verify that the space vehicle is ready for launch. The tests shall consist of a dry countdown with suited astronaut participation. No propellants or cryogenics will be transferred. The tests are scheduled for the fifteenth week of checkout.

5.9.2 Required Equipment - same as para. 5.2.2.

5.9.3 Radio Frequency Interference Tests (RFI) - Tests will be performed on all communications, telemetry, radar, and tracking systems in the spacecraft and ground facilities. These tests will verify that interference between RF systems shall not degrade spacecraft operations. The tests are scheduled for the fifteenth week of checkout at AMR.

RFI tests with squib simulators - All radiating systems will be activated and operated in normal modes including switching. Tests will be repeated with live squibs and safing plugs - The radiating systems will be activated with armed pyrotechnic circuits. The squibs will be examined to verify that they have not fired.

5.9.4 Required Equipment

Class III - Checkout Equipment, Class IV - Servicing Equipment. The checkout equipment will be capable of isolating malfunctions of combined subsystems down to the replaceable element level. The servicing equipment will supply fluids, cooling, etc.

Class IV
a. Fluid and gas supply unit
b. Equipment cooling unit

Class III
c. Computer equipment
d. Digital command system
e. Data collection system
f. Data link
g. Display equipment
h. Closed circuit TV
i. Field strength measurement and spectrum analysis equipment
j. Squib simulators - To simulate squib electrical characteristics.

5.9.5 Combined Subsystem Functional Tests - Same as para. 5.8.3.

5.9.6 Required Equipment - Same as para. 5.8.4.

5.9.7 Joint Flight Acceptance Composite Tests - These tests will be performed in an integrated sequence with the launch vehicle tests. The tests will include an integrated spacecraft test and a mission simulation test and will be performed just prior to launch countdown.

5.9.7.1 Integrated S/C Tests - To verify spacecraft module interfaces and to test all subsystem modes of operation.

a) Alignment verification.
b) Leak check.
c) Communications and instrumentation check.
d) Environmental Control Subsystem.
e) N & G Subsystem.
f) S & C Subsystem.
g) Propulsion Subsystem.
h) Crew Systems.

5.9.7.2 Simulated Countdown - These tests will consist of the simulated final launch operations and subsystem confidence tests. The countdown is performed on a contracted time scale.

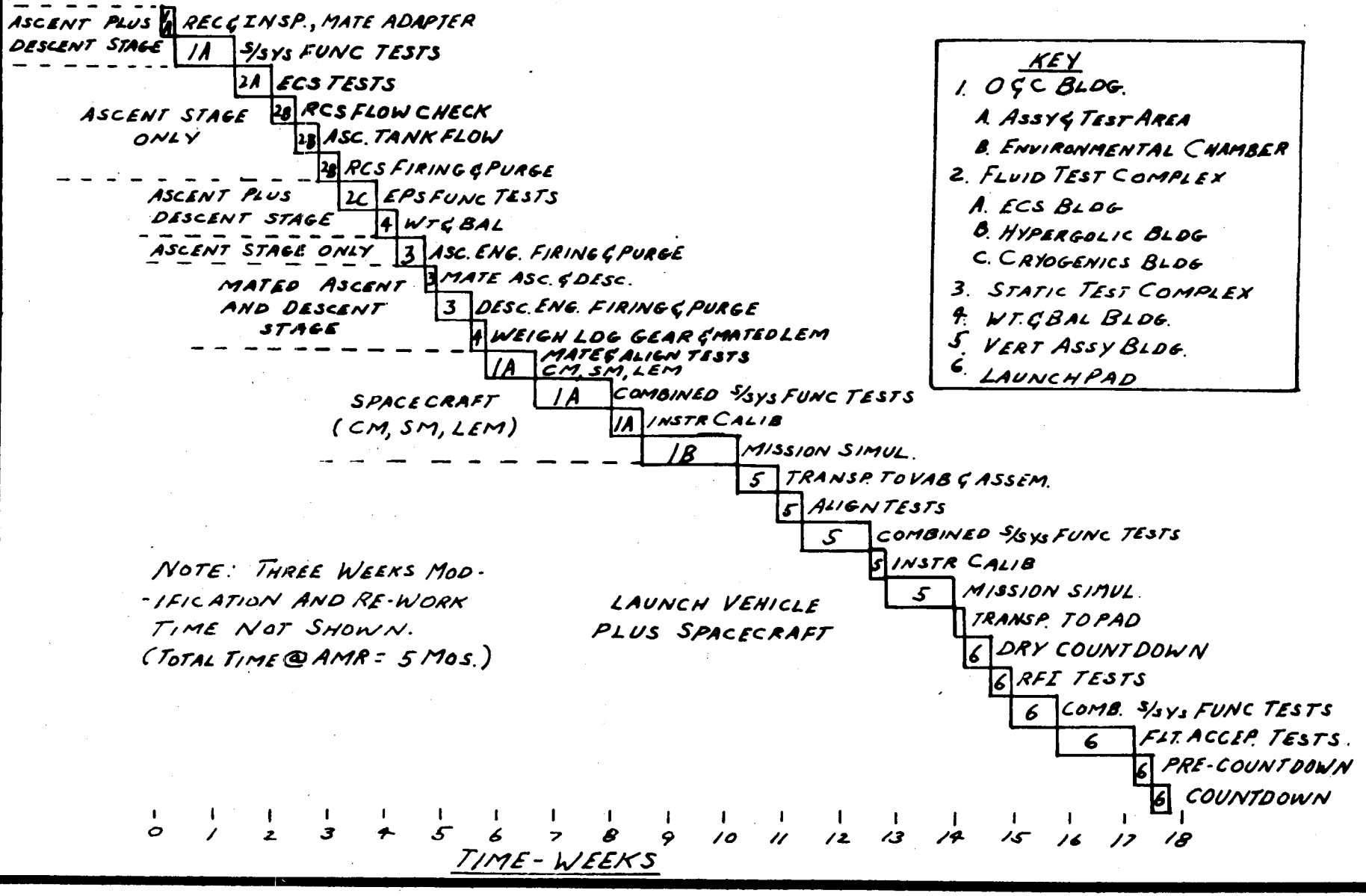
5.9.7.3 Mission simulation tests - Same as para. 5.2.5.

5.9.8 Required Equipment - Same as para. 5.2.2.

5.9.9 Countdown - Tests will be performed during countdown until immediately prior to launch consisting of final launch operations and subsystem readiness verification. The objective is a successful launch.

5.9.10 Required Equipment - Same as para. 5.2.2.

LEM AMR CHECKOUT PLAN

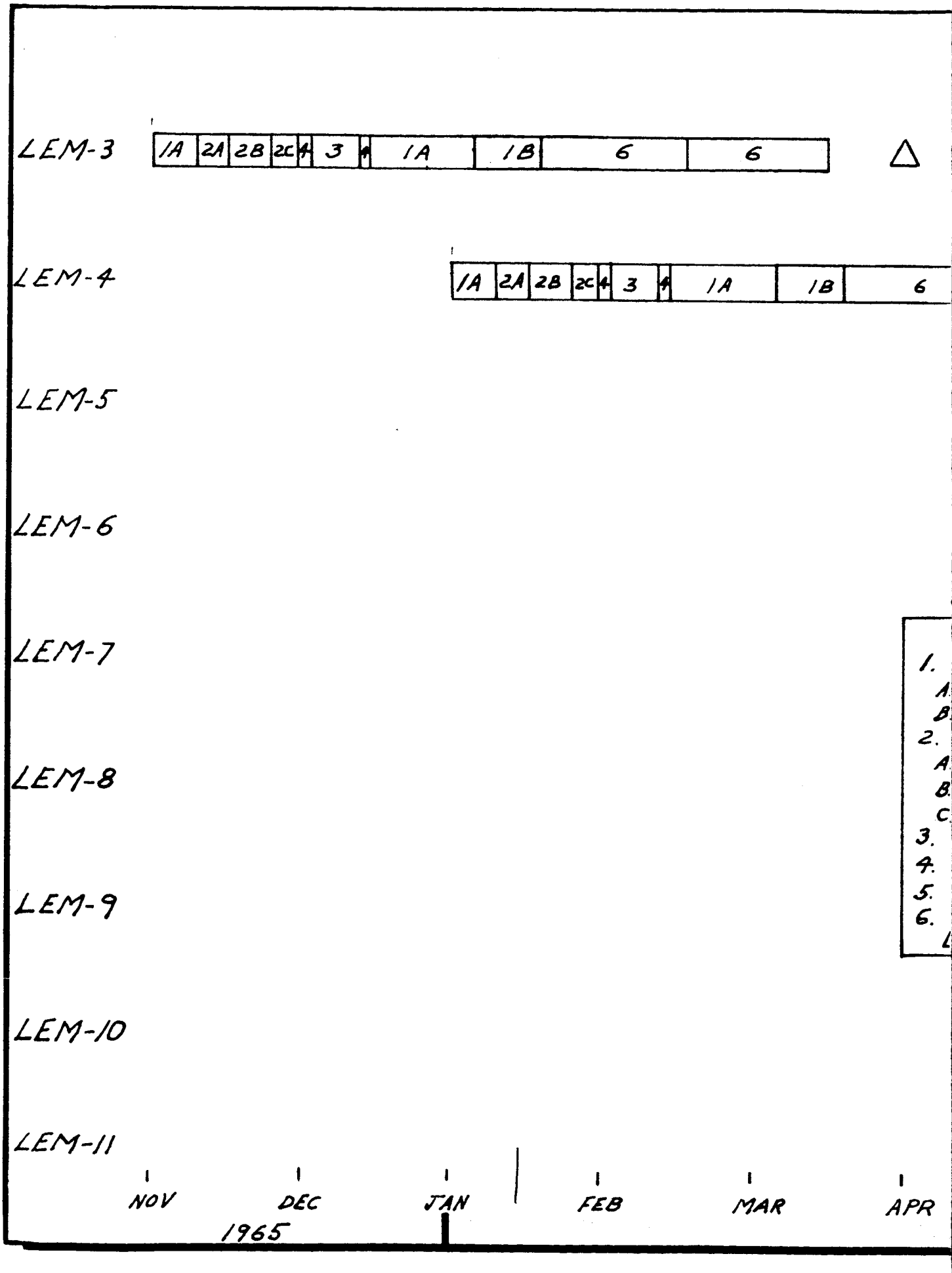


KEY

1. O & C BLDG.
   - A. ASSY & TEST AREA
   - B. ENVIRONMENTAL CHAMBER
2. FLUID TEST COMPLEX
   - A. ECS BLDG
   - B. HYPERGOLIC BLDG
   - C. CRYOGENICS BLDG
3. STATIC TEST COMPLEX
4. WT. & BAL BLDG.
5. VERT ASSY BLDG.
6. LAUNCH PAD

NOTE: THREE WEEKS MODIFICATION AND RE-WORK TIME NOT SHOWN. (TOTAL TIME @ AMR = 5 MOS.)

FIG 5-1


LEM-3
1A
2A
2B
2C
4
3
4
1A
1B
6
6
LEM-4
1A
2A
2B
2C
4
3
4
1A
1B
6
LEM-5
LEM-6
LEM-7
1.
A
B
2.
A
B
C
3.
4.
5.
6.
LEM-8
LEM-9
LEM-10
LEM-11
NOV
DEC
JAN
FEB
MAR
APR
1965

	6	△

1A	2A	2B	2C	4	3	4	1A	1B	6

1A	2

KEY

O&C BLDG.
ASSY & TEST AREA
ENVIRONMENTAL CHAMBER
FLUID TEST COMPLEX
ECS BLDG.
HYPERGOLIC BLDG
CRYOGENICS BLDG
STATIC TEST COMPLEX
WT & BAL BLDG.
VERT ASSY BLDG.
LAUNCH PAD
△ LAUNCH

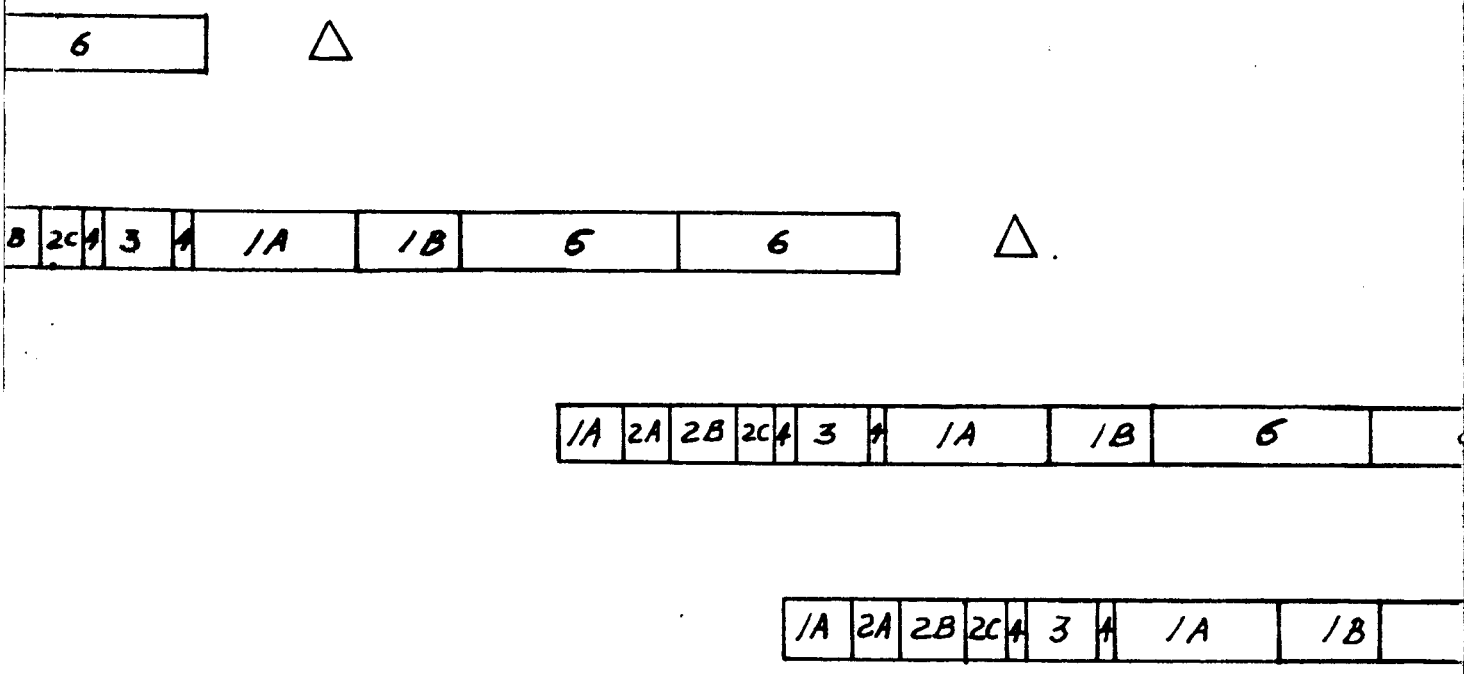
MAY | JUN | JUL | AUG | SEPT | OCT

1966

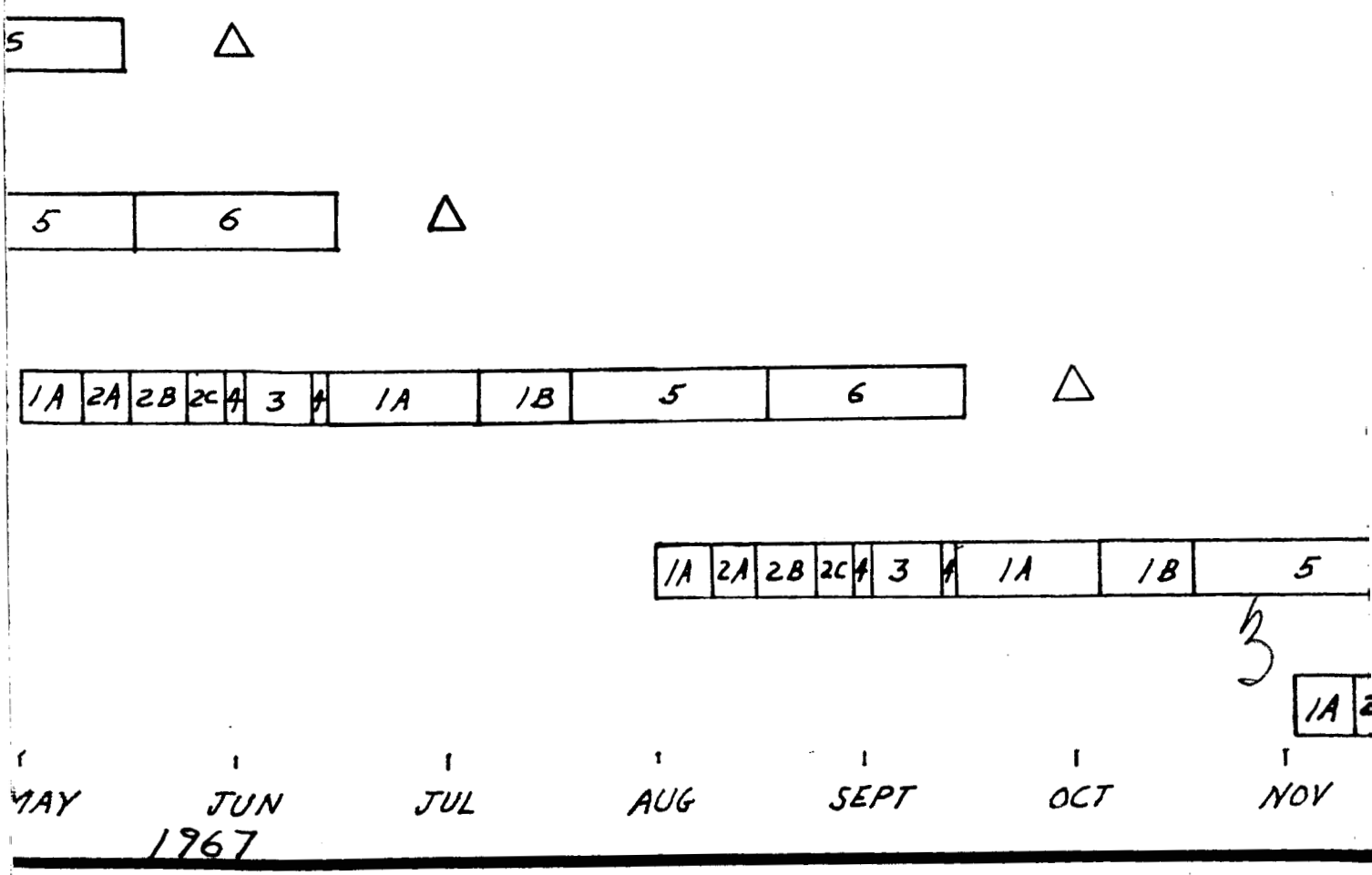
[redacted]

FIG. 5-2

LEM AMR FACILITIES UTILIZATION SCHEDULE



[redacted]


5
5
6
1A
2A
2B
2C
4
3
4
1A
1B
5
6
1A
2A
2B
2C
4
3
4
1A
1B
5
3
1A
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
1967

LEM-3

LEM-4

LEM-5

LEM-6

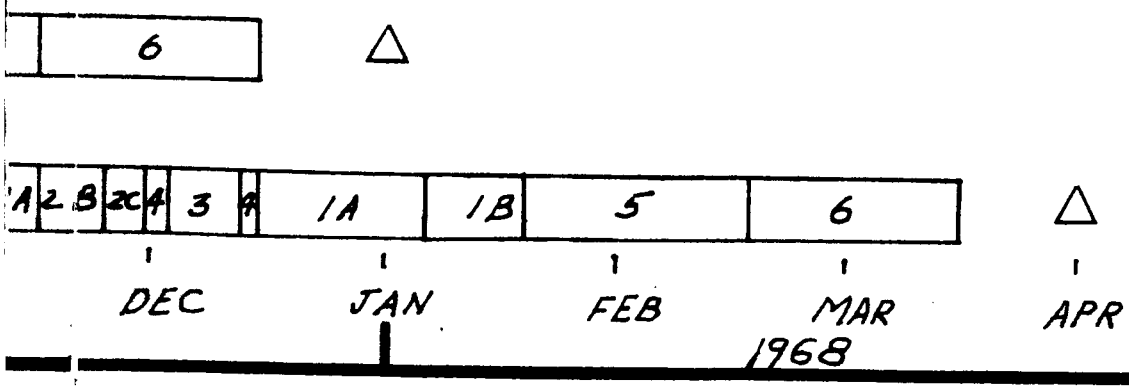
LEM-7

LEM-8

LEM-9

LEM-10

LEM-11



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DATE 5-15-68

6.0 MANNED SPACECRAFT CENTER

6.1 Test Facilities

Test facilities required at MSC include:

a) Electromagnetic Interference Test Facility suitable for testing LTA-7 alone and mated with the CM/SM.

b) Space Chamber Test Facility suitable for conducting thermal vacuum tests of LTA-7 alone and mated with the CM/SM.

c) PACE for integration tests of LTA-7 with the CM/SM.

d) Vibration Test Facility suitable for vibration tests of LTA-7.

e) Weight and Balance Facility.

f) LTA-7 Preparation Area including office area, high bay area, storage area, and bench test area.

6.2 Operational Facilities

The Integrated Mission Control Center at Houston will be required for control of flights of LEM-3 and subsequent. Unique requirements for LEM are not known at this time. If the I.M.C.C. is not available, the Mission Control Center at AMR may be used for Earth orbital flights.

7.0 ARNOLD ENGINEERING DEVELOPMENT CENTER

Rocket test facilities at the U.S. Air Force, A.E.D.C., will be used for the qualification tests of the Ascent stage engine and the Descent stage engine and for development tests of a cluster of the Reaction Control System. All tests will be run using stand tankage for the hypergolic propellants, 50-50 hydrazine-UDMH and nitrogen tetroxide. It is understood that test cells T-4, J-2A and J-3 are rated to handle these propellants. These cells also provide the physical size, altitude and thrust capability necessary.

It is considered at this time that cell J-2A is most desirable because of its cold wall and high altitude soak capability. This is especially true for test of the RCS which will include a cluster of 4 nozzles (at 90° to each other in one plane) and a section of the spacecraft skin.

The schedule for occupancy of AEDC is given in Figure 1-3.

8.0 WHITE SANDS MISSILE RANGE

8.1 LEM Test Facility - Propulsion Test Area

The accomplishment of the Lunar Excursion Module Program requires the construction of a static firing test facility for system development of the Ascent Propulsion System, Descent Propulsion System and the Reaction Control System. The National Aeronautical and Space Administration, to implement this requirement, will develop a NASA Manned Spacecraft Test Area suitable for this development testing.

The site selected for this test facility is located within the boundaries of the White Sands Missile Range on the west flank of the San Andres Mountains in an area known as the Jornada del Muerto Basin in Dona Ana County, near Las Cruces, New Mexico.

The LEM test facility will be located in close proximity to the North American Aviation [redacted] test facility for the purpose of sharing a common propellant storage, water supply, electrical power and general administrative area.

It is expected that this test facility will be sufficiently complete to accept a descent stage, ascent stage, and RCS rig for hot firings under altitude simulation by July 1964.

Grumman Aircraft Engineering Corporation has given a contract to the Burns and Roe Company, an Architect and Engineering firm, for development of the LEM White Sands Missile Range Test Facilities Design Criteria. This document will be complete by May 21, 1963.

NASA will give a contract to the Army Corps of Engineers to design and construct the LEM Test Facilities at WSMR. The Corps of Engineers will subcontract design to an Architect and Engineering company. Grumman will supply the initial requirements and continually supply new or revised requirements thru Engineering Criteria documents and monitor the detail design and construction to determine effects of facility changes on the LEM program.

The requirements of the Propulsion Test Area and the Engineering and Preparation Building are provided in the "Facility Criteria for the Apollo LEM Test Facility, NASA MSC Test Area, WSMR, New Mexico". GAEC Report No. LED-2-1, 15 May 1963.

Essentially the Propulsion Test Area consists of four vertical static test stands with altitude simulation, supporting buildings and equipment and a control center. The Engineering and Preparation Building will provide office space for Grumman and related NASA and subcontractor personnel and will provide a high bay area to prep and modify the test articles and low bay supporting shops and storage area. This building will not only support tests in the Propulsion Test Area but also in the Hover Test Area and will be used to prep the articles for launch on Little Joe II.

8.2 LEM Test Facility - Hover Test Area

The requirements for facilities for hover tests at the WSMR-MSC Test Area are not identified at this time. More data will be available after the preliminary design study on LTA-9 is completed.

8.3 White Sands Missile Test Area

The test plan provides for unmanned sub-orbital flight tests of LEM-1 and LEM-2. The Little Joe II will be the boost vehicle and it will be launched from the Little Joe site on the White Sands Missile Range. The anticipated trajectory results in impact at a point approximately 50 miles downrange and will require participation of both north and south range tracking facilities for trajectory data and monitoring of the flight for range safety. The unique tracking capabilities required for this sub-orbital test and the modifications to the launch site (i.e., propellant fueling provisions) are being investigated and will be furnished in a Requirements for Work and Resources subsequent to confirmation of test plan.

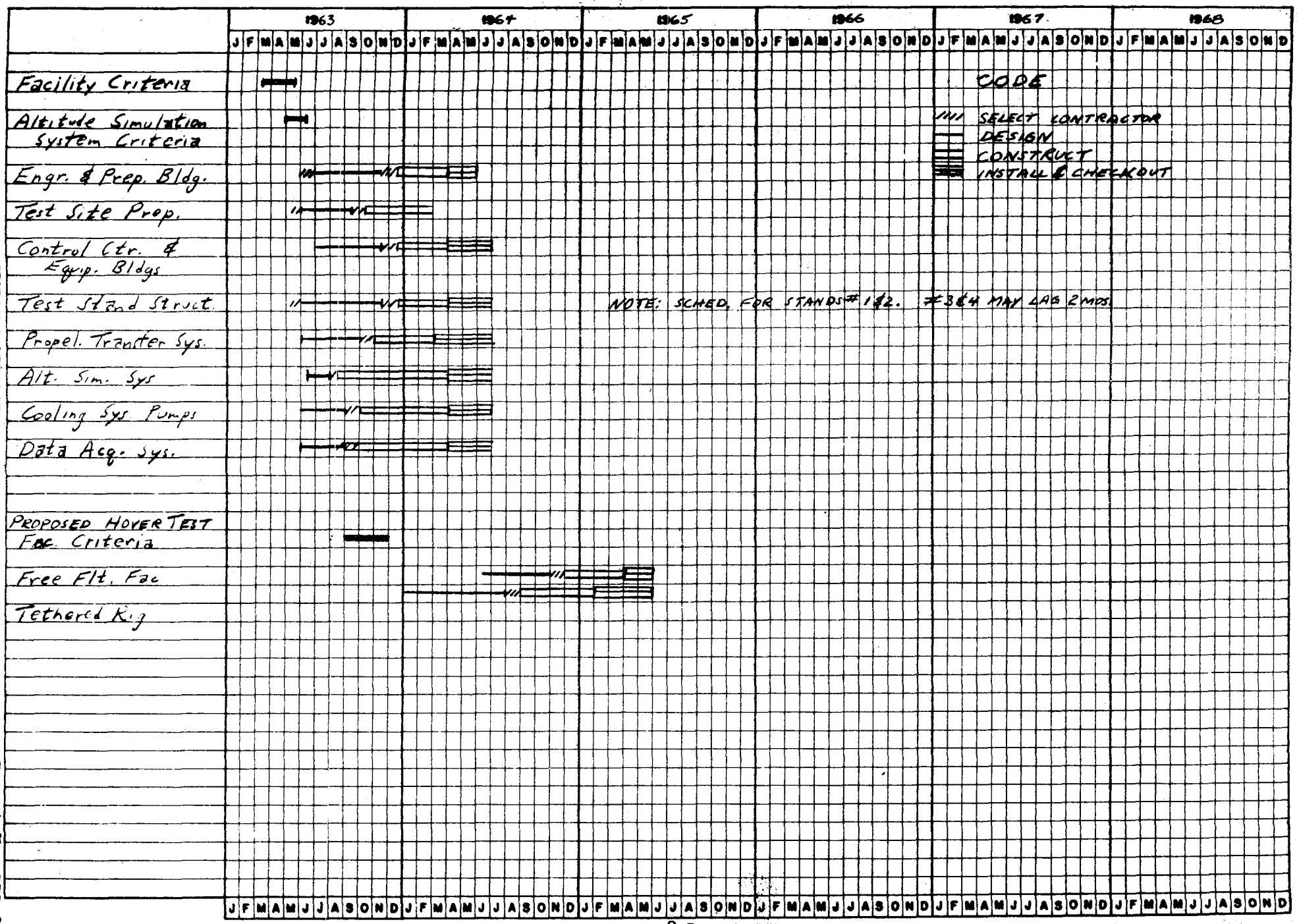

Fig. 8-1

ACQUISITION OF WSMR LEM TEST FACILITY

9.0 MARSHALL SPACE FLIGHT CENTER

Present plans call for mating the LTA-2 to a full scale dynamic model of the C-1B (and later the C-5) and determining the lateral and torsional modes and frequencies for the entire launch configuration. These modes are of concern at Stabilization and Control System frequencies for the launch vehicle (0 to 20 cps). The representation of the LEM for these tests will have accurate structural dynamic characteristics up to 30 cps. This test, including data acquisition and analysis, will be conducted by MSFC. Therefore, requirements for facilities at MSFC for these tests must be specified by MSFC. At present, responsibility and extent of instrumentation for the test specimen has not been determined.